Advantages of Embedded Linux in Industrial Automation and IIoT

Benson Hougland – Opto 22

Topics I'll Cover

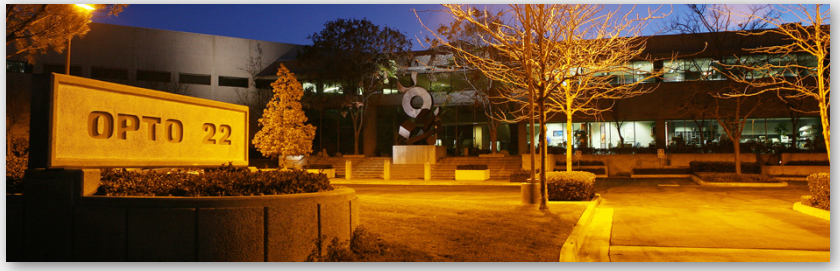
- Who is this guy and what is Opto 22?
- What is Industrial Automation? What about IIoT?
- What problems are we trying to solve here?
- How do we solve these problems?
- A case study application – Tale of Two Turbines
- How *groov* EPIC solved the problem
- Live Demonstration

About me and my company

Benson Hougland, VP Marketing & Product Strategy

Opto 22, Temecula, CA USA – www.opto22.com

- 44 year technology innovator, from **SSRs** to **I/O**, **control systems**, software, mobile, & **IoT**
- Market leader of intelligent, distributed I/O systems: **100M I/O** at over **10K** global customers
- Reputation for quality and reliability backed by **lifetime warranty** on solid-state I/O
- Unique in industry to combine **capabilities in OT**
  – ruggedness, reliability, flexibility – **with IT**
  – networking, protocols, accessibility
- Responsible for many firsts in our industry

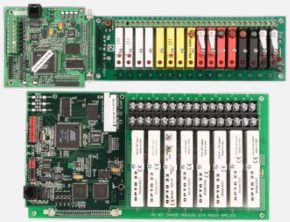


MADE IN THE USA


MADE IN THE USA

Many Firsts

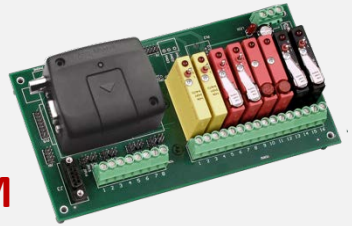
Plug-in I/O



Founding Member

Ethernet I/O

M2M

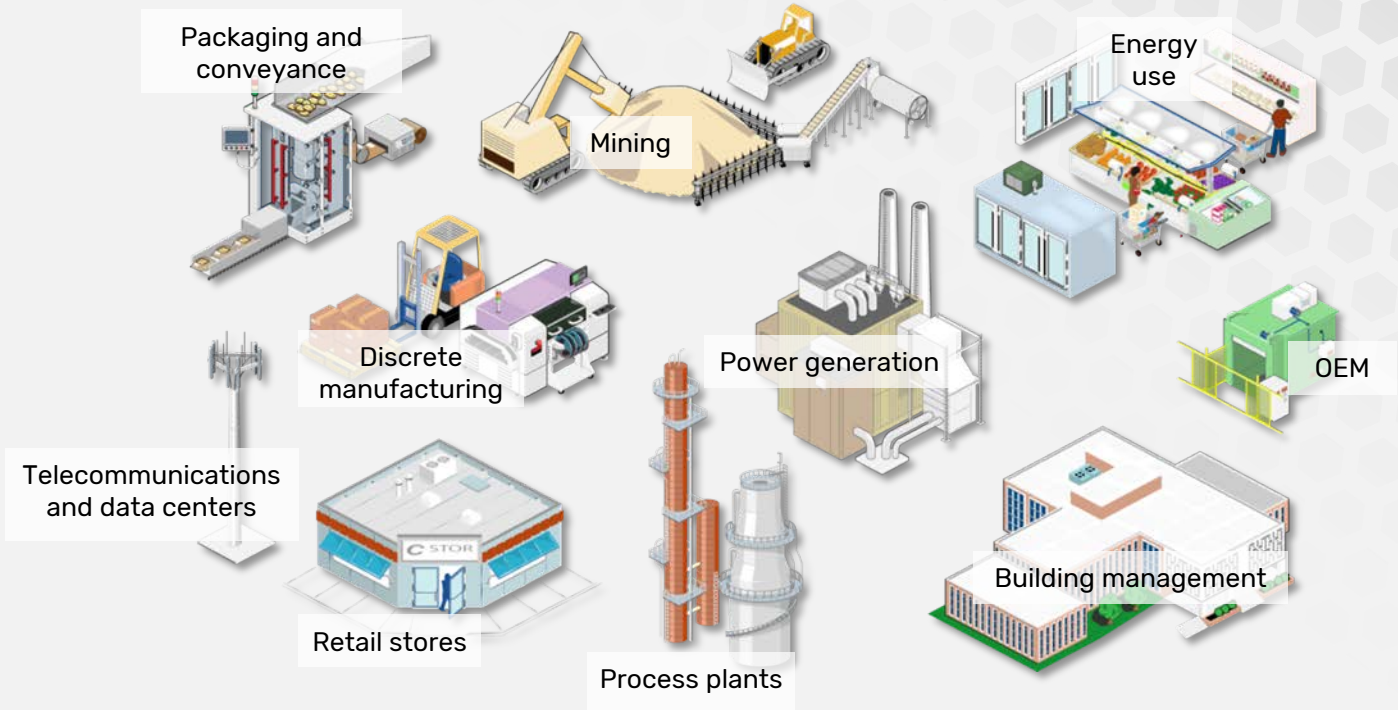


EPICs

PACs

Industries Served

- Manufacturing
- Retail Outlets
- Pharmaceutical
- Petrochemical
- Food & Beverage
- Commercial buildings
- Government buildings
- Pulp & Paper
- Telecom
- Semiconductor
- Utilities




Water

Entertainment

Transportation

Oil & Gas

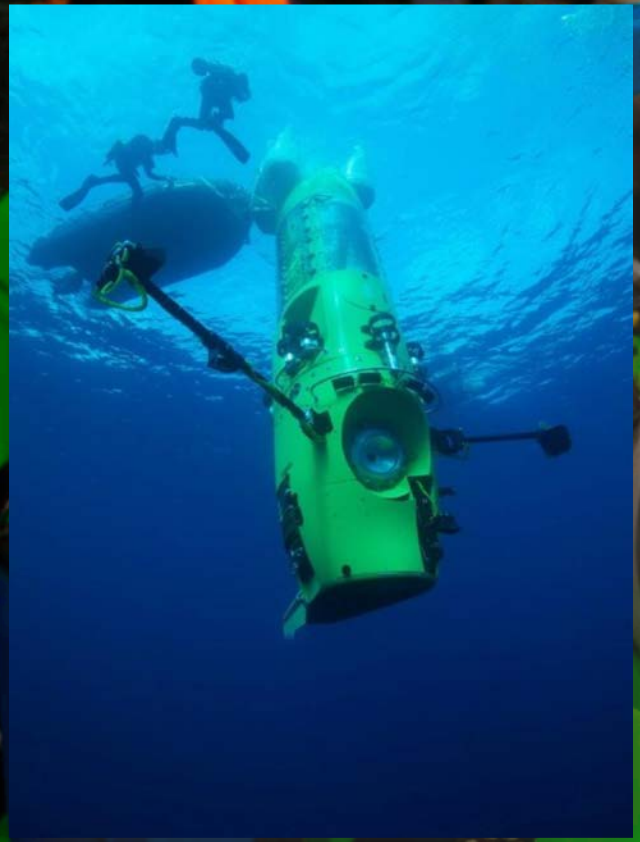

Communications

Buildings & Facilities

Food & Beverage


Manufacturing

Special Projects



Special Projects

What is Industrial Automation and the IIoT?

What is Industrial Automation?

- Industrial automation deals primarily with the automation of manufacturing, process control, and material handling processes.

  Industrial automation is to replace the decision making of humans and manual command-response activities with the use of mechanized equipment and logical programming commands.

Wikipedia, 2019

Automation Tools of the trade

- PLC – programmable logic controller
- PAC – programmable automation controller
- IPC – industrial PC

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What is the Internet of Things (IoT)?

- The internetworking of physical devices, vehicles, buildings and other items–embedded with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data

Wikipedia, 2016

- The ability of “things” to sense, communicate, and control.

Benson Hougland, TEDx Temecula, 2014

TEDx

What is the Internet of Things? And why should you care? | Benson Hougland | TEDxTemecula

733,420 views

7.2K 287 SHARE SAVE

What is the Industrial IoT (IoT)?

- The industrial internet of things (IIoT) refers to interconnected **sensors, instruments, and other devices** networked together with computers' **industrial applications**, including manufacturing and energy management.

- This connectivity allows for **data collection, exchange, and analysis**, potentially facilitating improvements in productivity and efficiency as well as other economic benefits

Wikipedia, 2019

The IIoT Modular Architecture

Layered modular architecture IIoT	
Content layer	User interface devices (e.g. screens, tablets, smart glasses)
Service layer	Applications, software to analyze data and transform it into information
Network layer	Communications protocols, wifi, cloud computing
Device layer	Hardware: CPS, machines, sensors

Courtesy of Industrial Internet of Things, Wikipedia, 2019

Industrial IoT Tools of the Trade

- Gateways, sensor systems
- Ignition by Inductive Automation
- Node-RED by IBM Emerging Labs
- Cloud Platforms
  - AWS IoT
  - IBM Watson
  - Microsoft Azure IoT
  - PTC Thingworx

Ignition by inductive automation

Node-RED

What's the problem?

Issues plaguing Industrial Automation & IIoT

Artificial Intelligence

Industrial Internet of Things

Cloud Computing

The future is here.

Machine Learning

Data Analytics

Remote Control

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Networking

Brownfields

Data access

Security

Uh-oh.

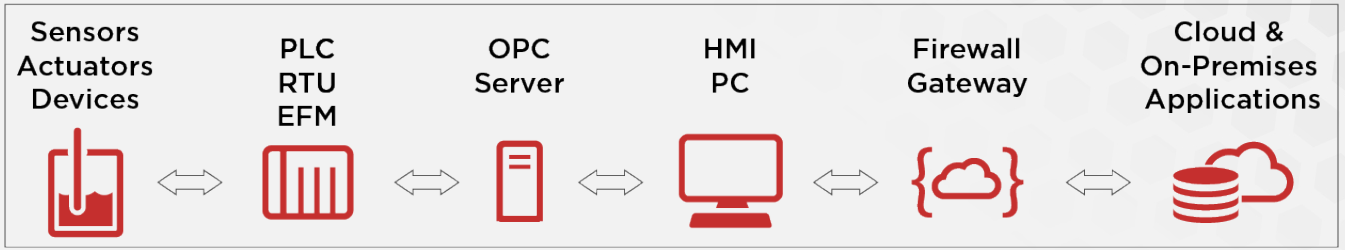
Rip & Replace

Operations

Proprietary protocols

PROBLEM

Existing systems are complex, costly, & difficult to maintain



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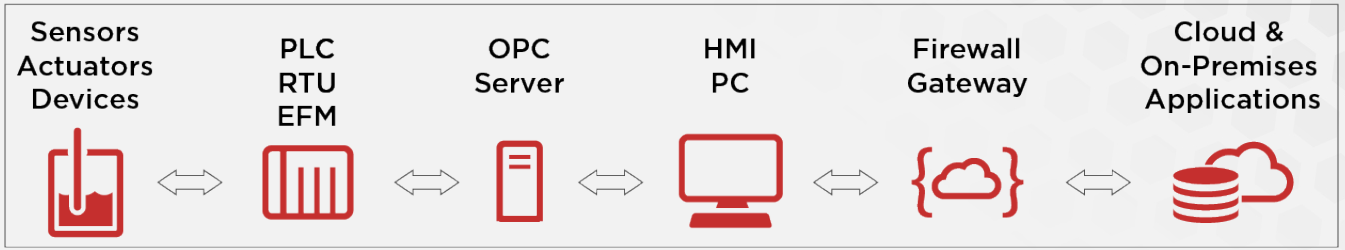

- Proprietary OSs & RTOSs
- Multi-domain expertise required
- Security nightmare
- Unable to scale
- Licensing costs and manageability

How do we solve these problems?

Embrace Embedded Linux.

groov® EPIC

The World's First **E**dge **P**rogrammable **I**ndustrial **C**ontroller

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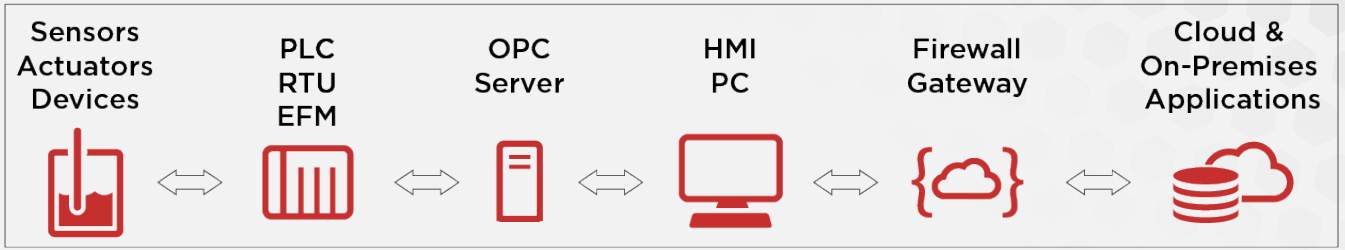
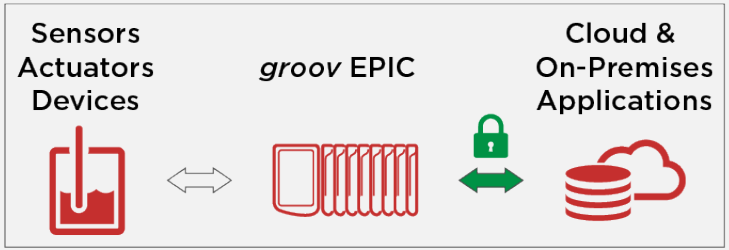
Existing systems are complex, costly, & difficult to maintain



EPICs are simpler, more secure, & manageable

SOLUTION



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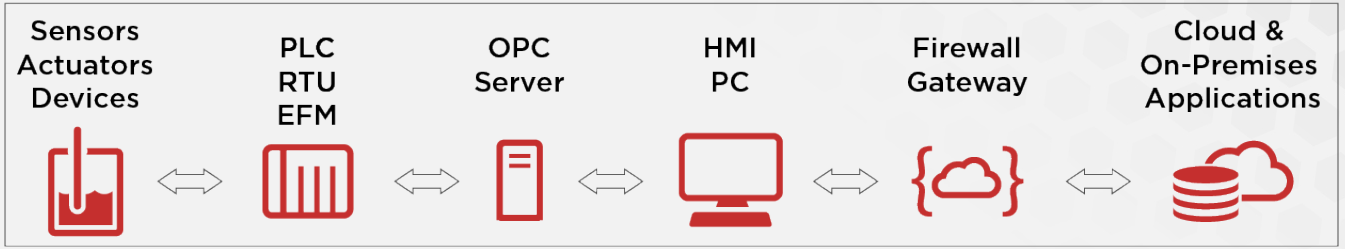
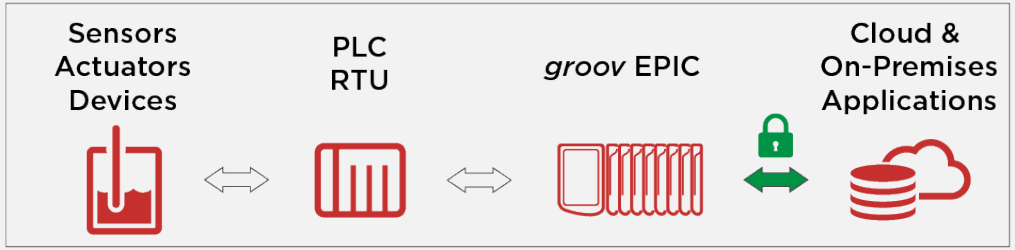


EPICs can also secure legacy systems

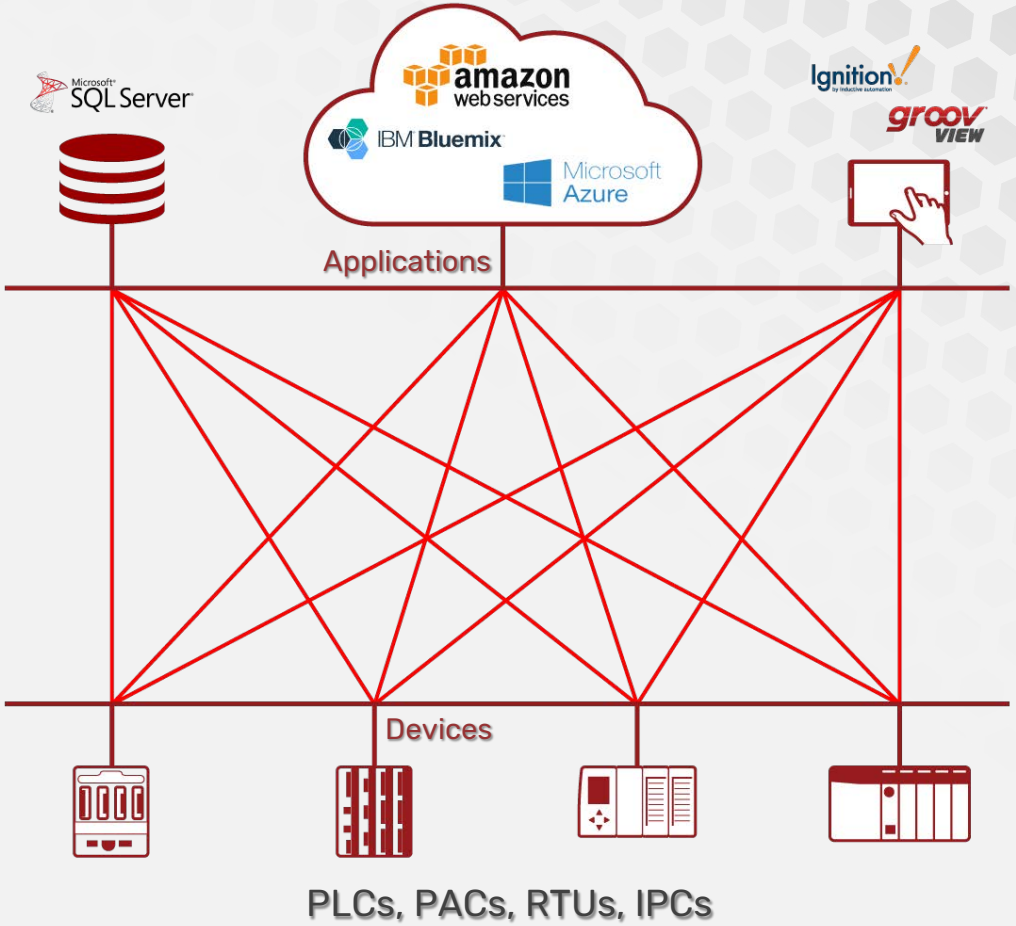
SOLUTION



PROBLEM

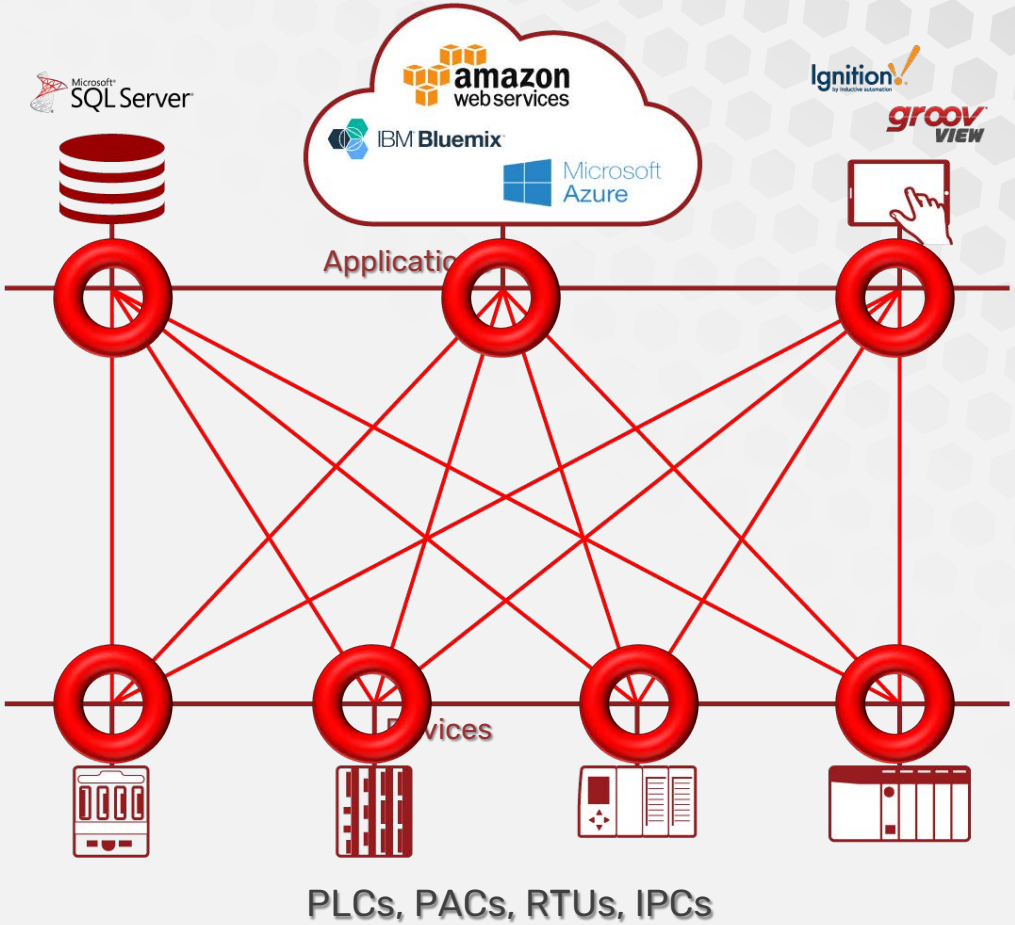
Applications Tightly Coupled to Devices

- Direct connections required
- Inefficient poll-response
- Multiple, insecure open ports
- Unencrypted traffic
- Difficult to manage & maintain
- Complex architecture
- Shifts responsibility to IT



PROBLEM

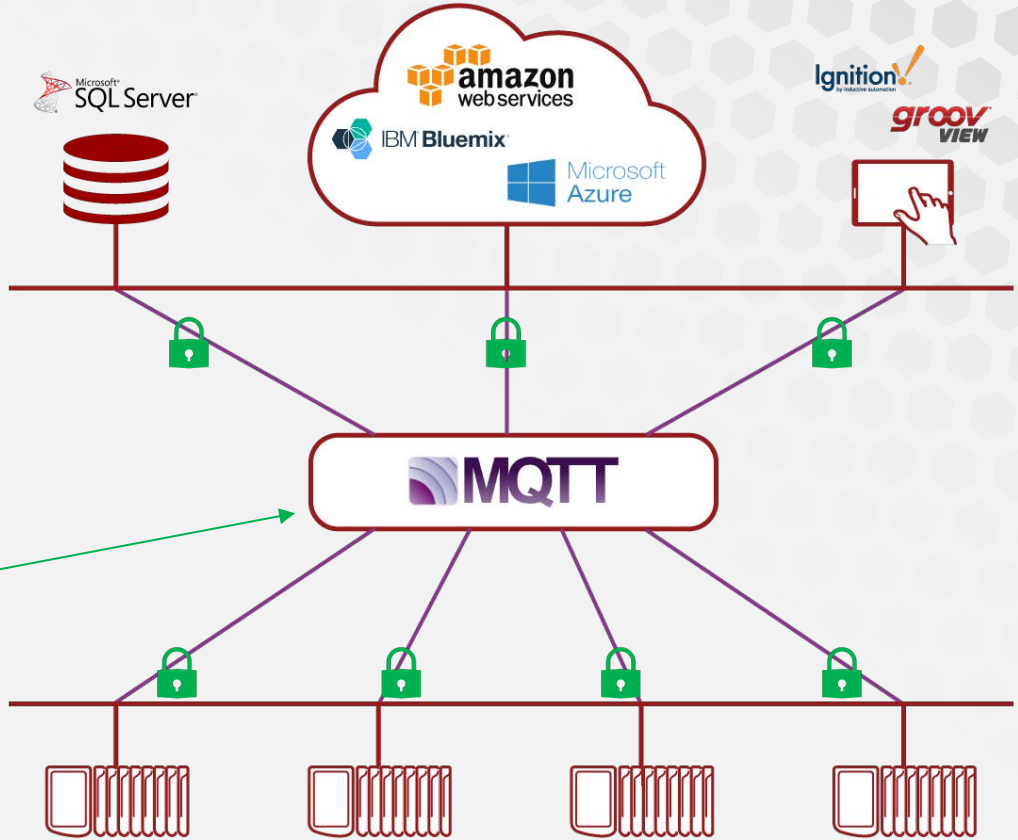
Numerous security vulnerabilities and points of access to manage



SOLUTION

Applications Decoupled from Devices

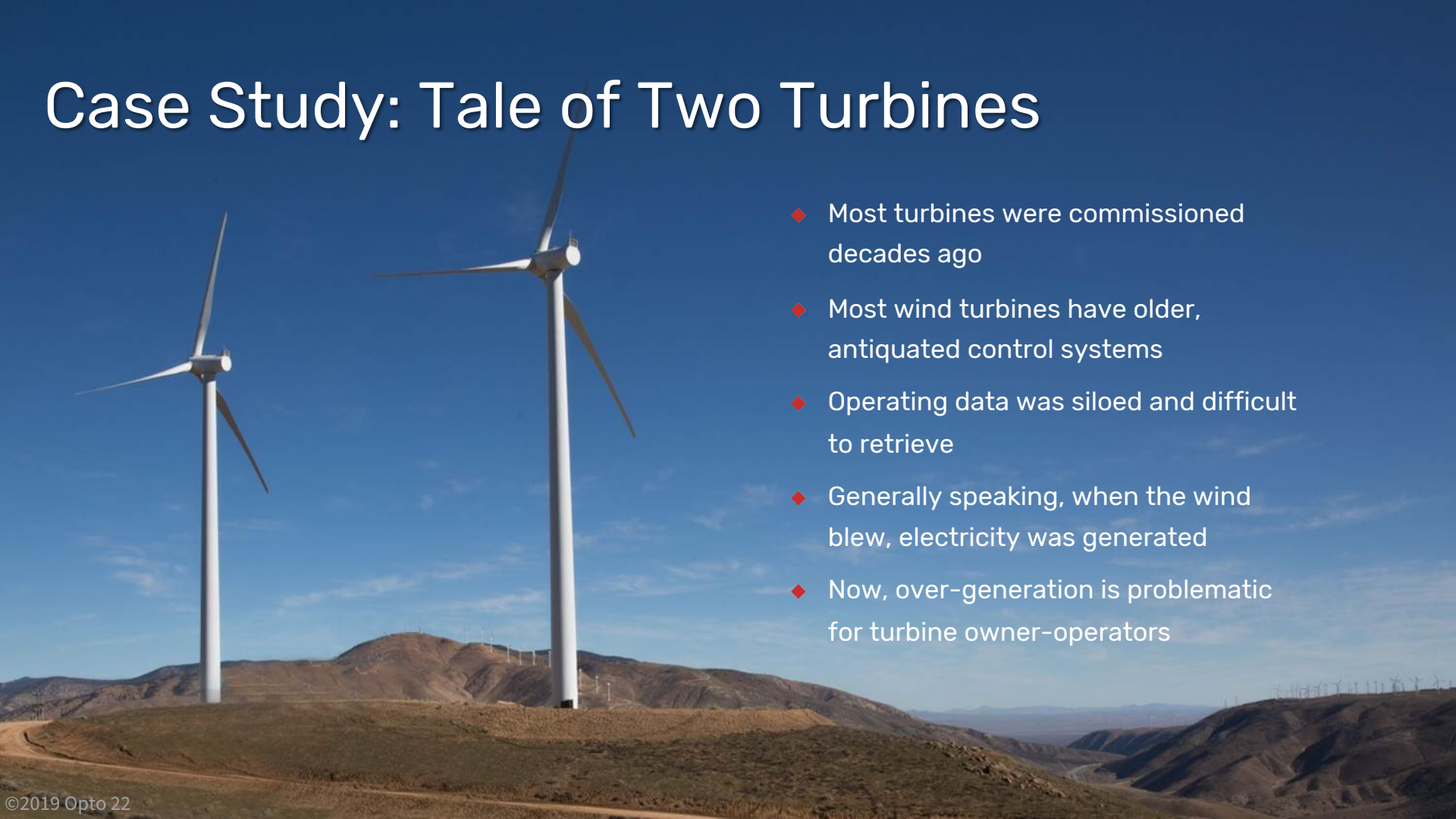
- Efficient
  - Publish-subscribe, bi-directional
- High performance
  - Data transmit only on change
- Secure
  - Only ONE secure open port
  - Only ONE place to manage & maintain user and data access



Case Study

Wind Turbines

Case Study: Tale of Two Turbines



- Most turbines were commissioned decades ago
- Most wind turbines have older, antiquated control systems
- Operating data was siloed and difficult to retrieve
- Generally speaking, when the wind blew, electricity was generated
- Now, over-generation is problematic for turbine owner-operators

California's Renewable Energy

Legislated Energy Goal

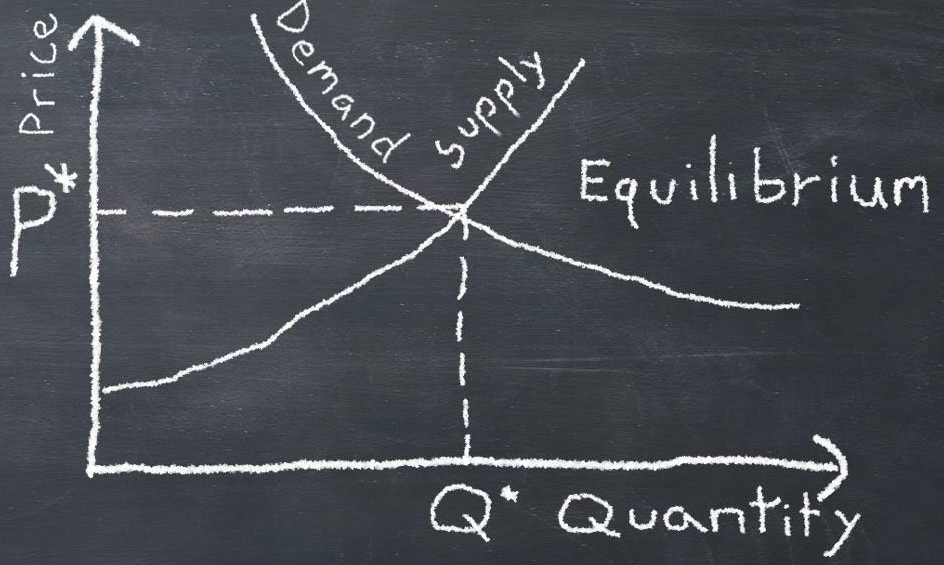
- 33% of energy from renewable sources by 2020
  - Solar, Wind, Hydroelectric, Geothermal
- However…
  - Generation is variable and not always needed
  - Cannot store excess generation
  - Electricity must be produced and used at the same rate

California ISO (CAISO)

CAISO attempts to predict the future:

- Available supply
- Expected demand
- Weather's impact
- Renewables variability
- Then, determines which generating assets to dispatch

Finding Equilibrium



Supply & demand management tool

- Vary the *spot price* of electricity for generation producers in real time
- Price can fluctuate minute by minute
- Determined by CAISO

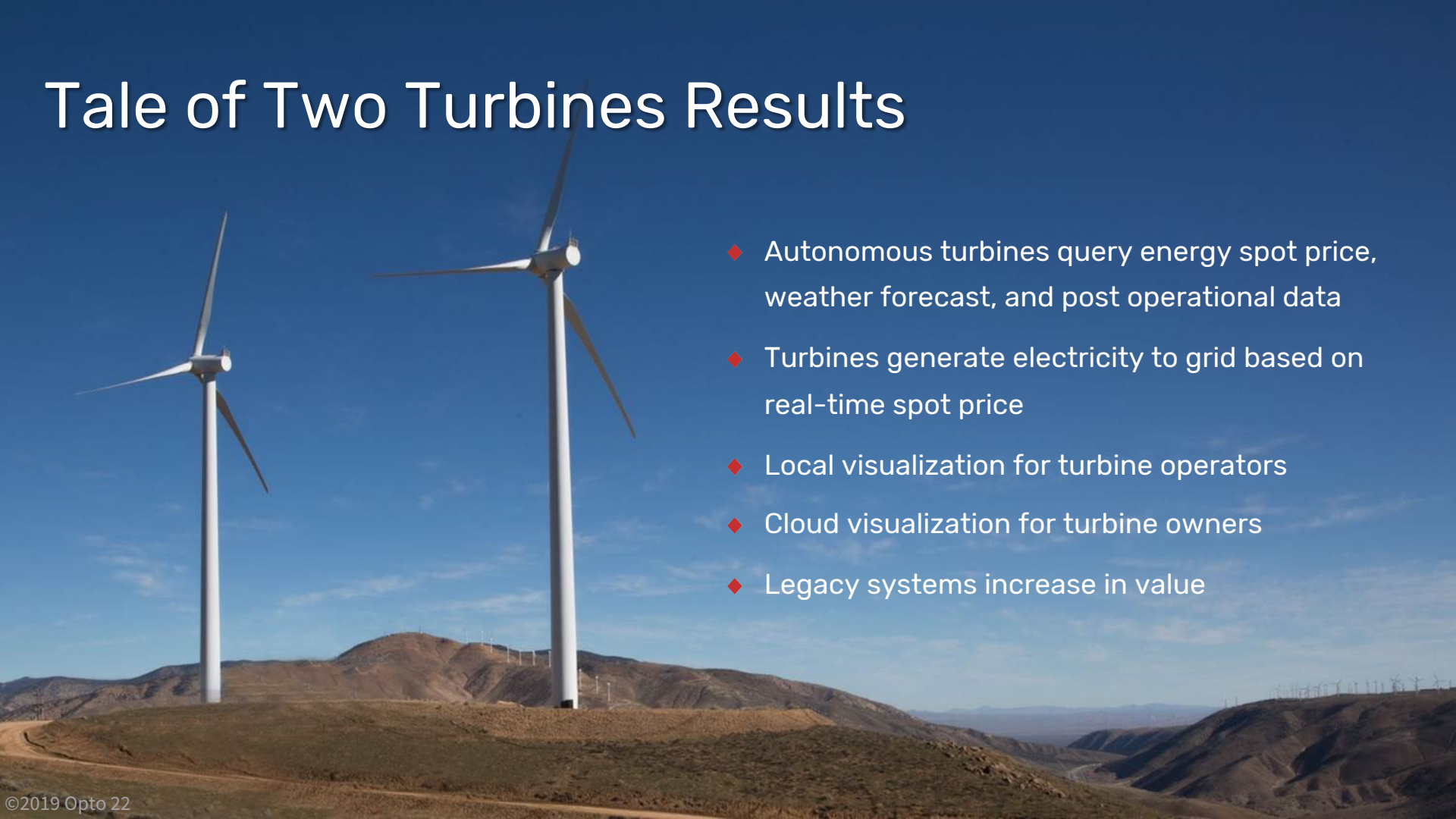
Typical Scenario

- Electricity supply exceeds demand
- Curtailment dispatched by CAISO market price, sometimes to below $0
- Legacy wind turbines have no communications or edge processing
- Owner-operators write a check if generating

What if they apply IA and the IIoT?

- Get physical inputs: generation, blade pitch, temperature
- Combine with data inputs: market price, weather forecast
- Set outputs: change turbine blade pitch, curtail turbine
- Report data to cloud IoT platforms for predictive maintenance

Tale of Two Turbines Results



- Autonomous turbines query energy spot price, weather forecast, and post operational data
- Turbines generate electricity to grid based on real-time spot price
- Local visualization for turbine operators
- Cloud visualization for turbine owners
- Legacy systems increase in value

How’d they do it?

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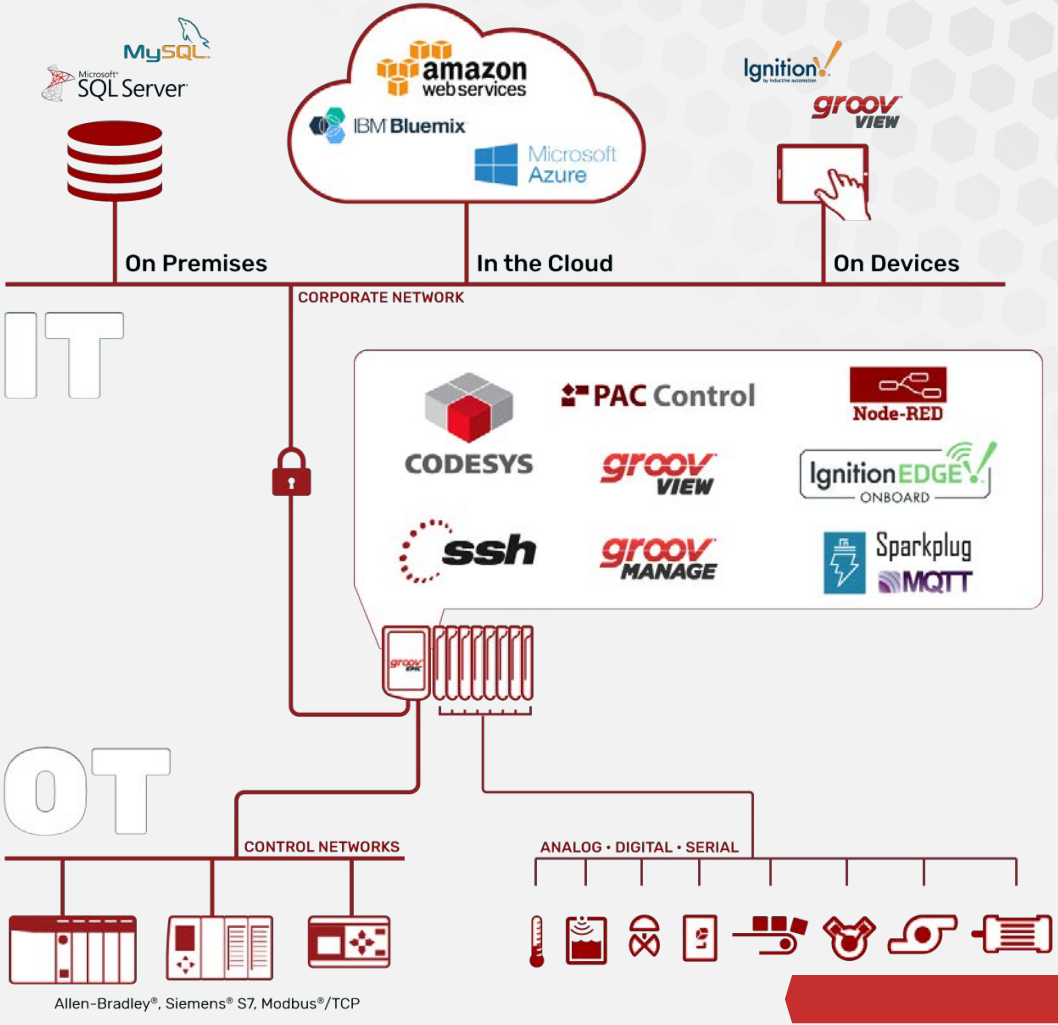
System Architecture

Where does it fit?

System Architecture



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Courtesy of Industrial Internet of Things, Wikipedia, 2019

groov EPIC Hardware

Overview of EPIC's hardware

High Performance Controller

- Industrial Quad-core ARM Cortex A9
- Linux OS with PREEMPT-RT
- 2GB RAM
- 6GB useable SSD
- Power-fail safe file system
- Dual Gigabit Ethernet
- Dual USB
- Temperature rated -20 to 70°C

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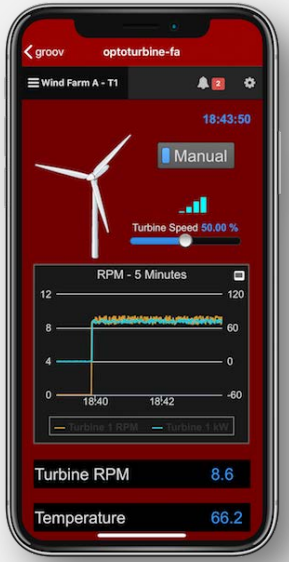
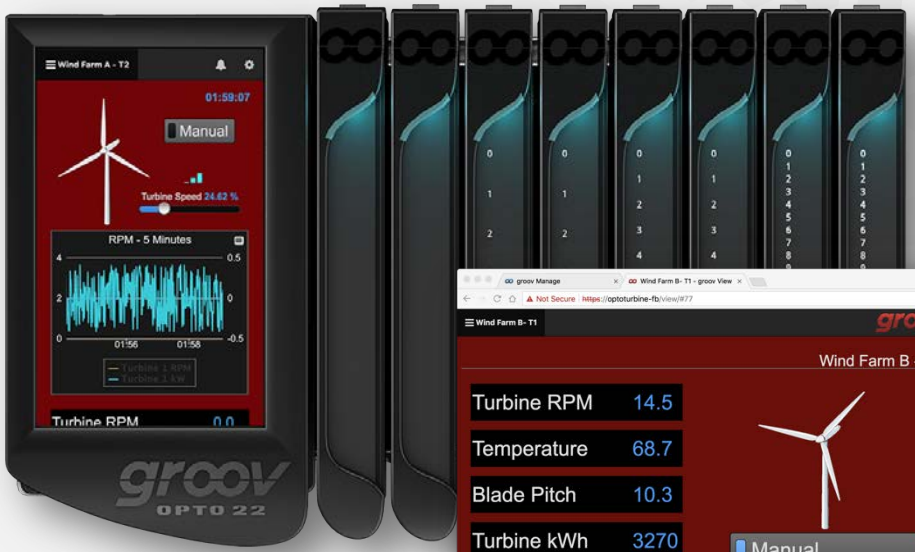
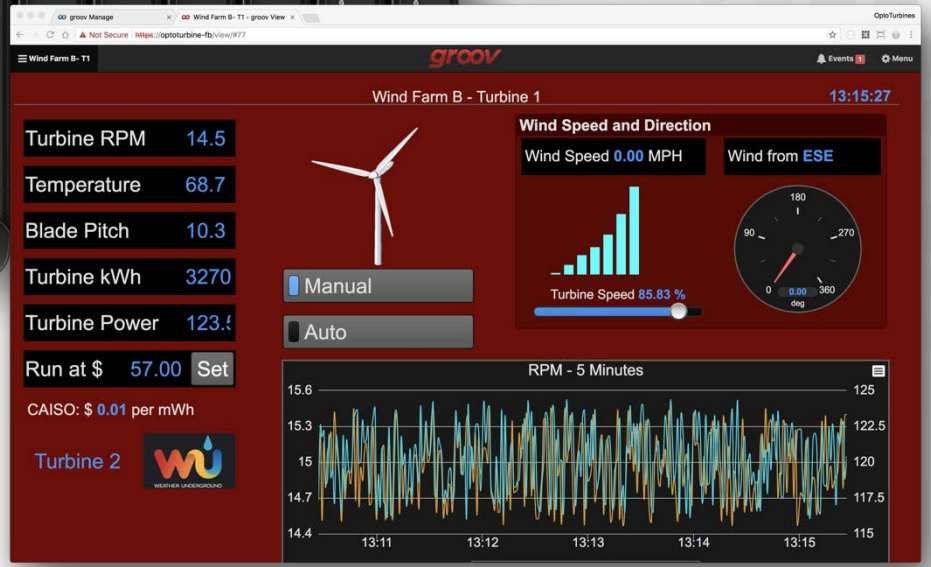
Integrated HDMI-based touch display

- High-resolution color touchscreen display
- Displays *groov* Manage pages
  - Configure processor and modules
  - Troubleshoot I/O
  - Module specs and wiring diagrams
- Displays *groov* View screens
- HDMI port for external display







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View on mobile, web browsers, and front display

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groov I/O Modules

- 4-24 channels per module
- Isolated and non-isolated versions
- Hot swappable
- Many I/O variations
  - Analog in/out
    - flow, pressure, level, position
  - Discrete in/out
    - presence, status, on-off, start-stop
  - Serial
    - barcode, scale, RFID reader
  - Temperature
    - thermocouple, RTD, thermistor

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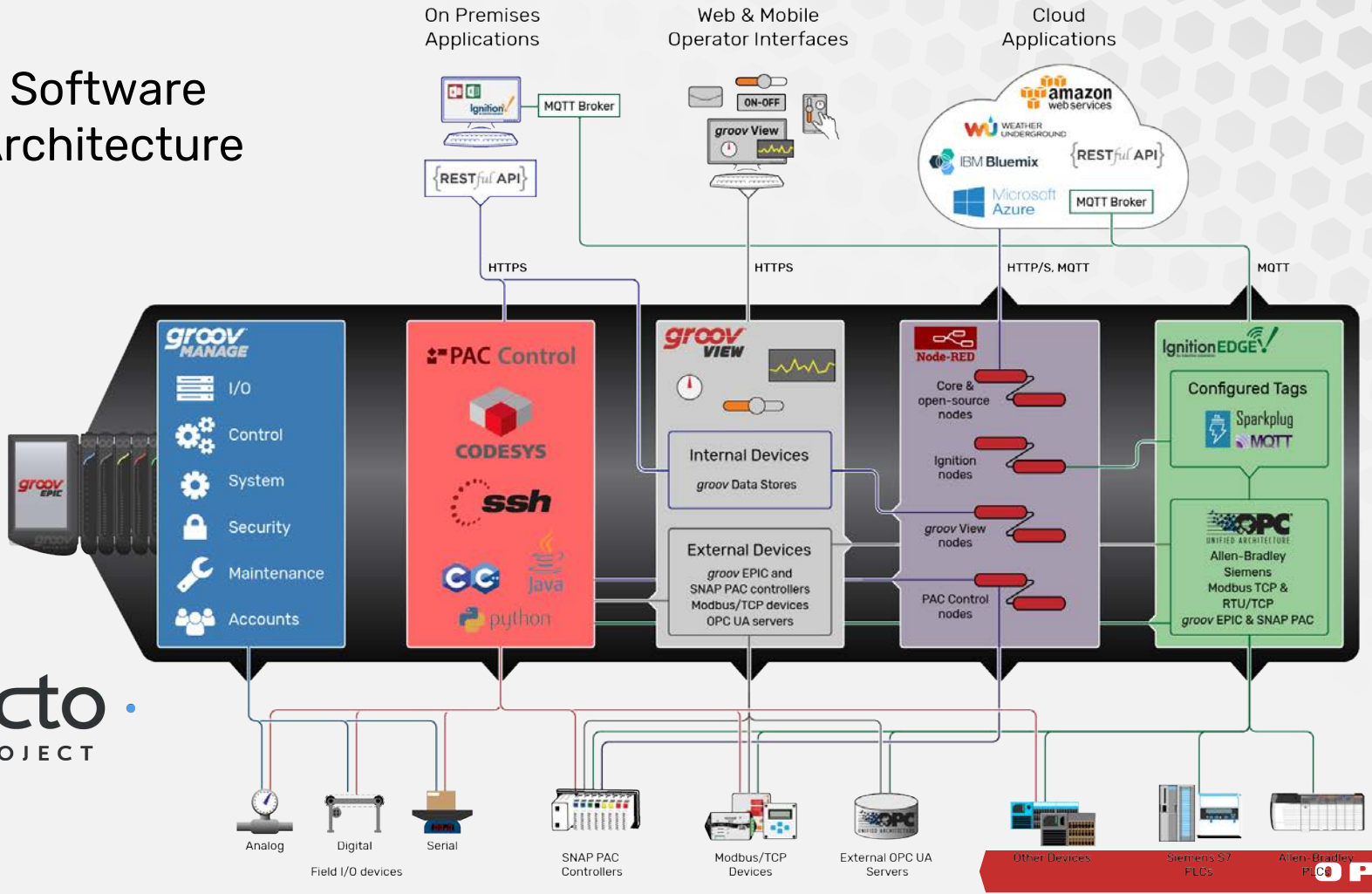
Exploded View

- Easy to assemble
- Mount on SS chassis
  - 0, 4, 8, 16 module versions
- Industrial Approvals
  - UL Hazardous Locations
  - Class 1 Div 2
  - CE approved
  - ATEX Compliant

groov EPIC Software

Software Architecture



yocto PROJECT

What does the software do?

- Brings key capabilities to an industrial controller:
  - Manage, commission, and troubleshoot the system
  - Develop and run real-time control strategies
  - Create and view mobile and web operator interfaces
  - Build & deploy IoT applications quickly
  - Connect to legacy PLCs
  - Publish & subscribe data with MQTT/Sparkplug
  - Secure existing OT devices and infrastructure

CODESYS

groov VIEW

groov MANAGE

Node-RED

Ignition EDGE by inductive automation

ssh

node JS

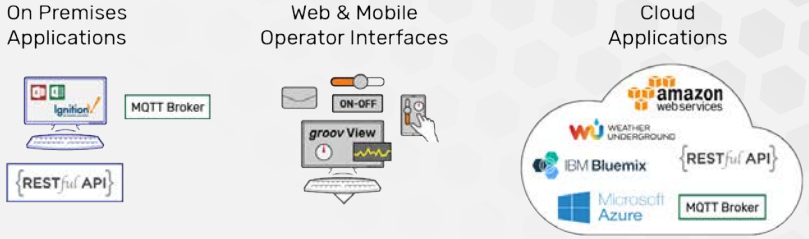
OPC UNIFIED ARCHITECTURE

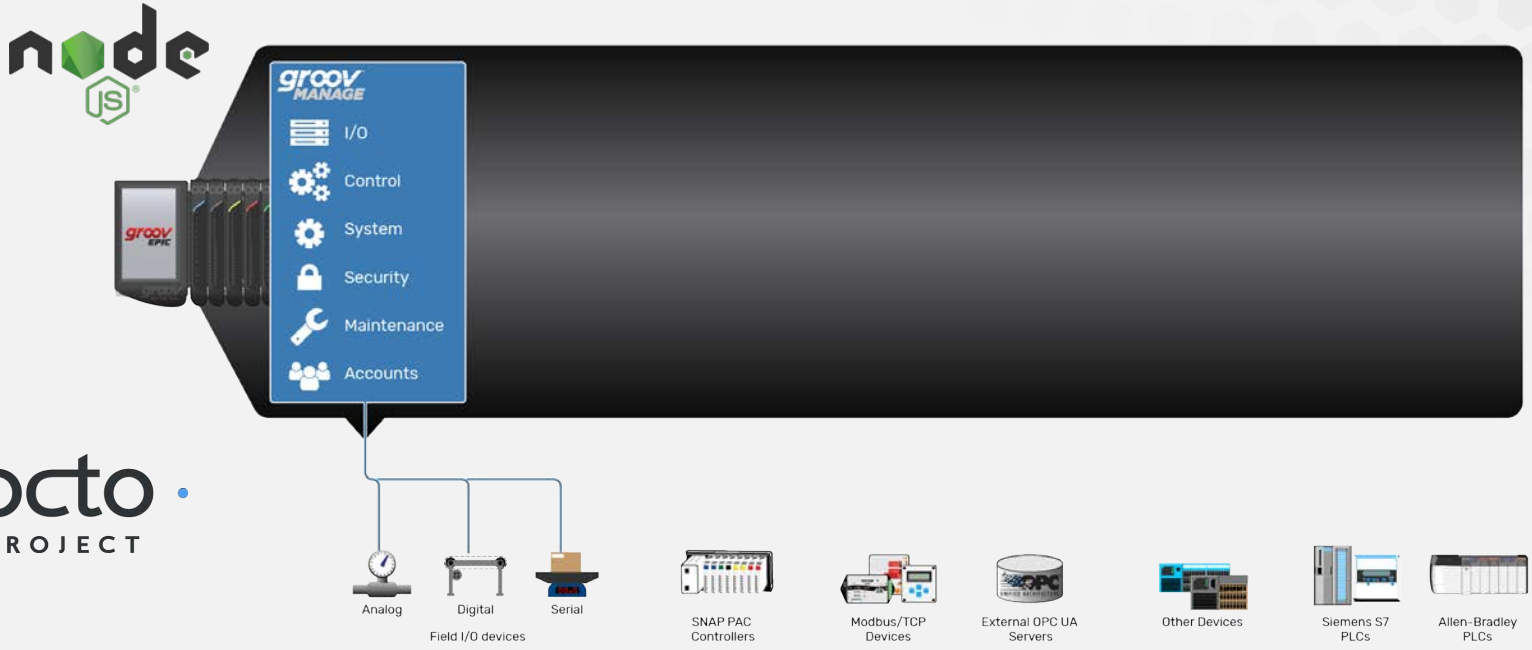
MQTT

Sparkplug MQTT Topic & Payload Definition

PAC Control

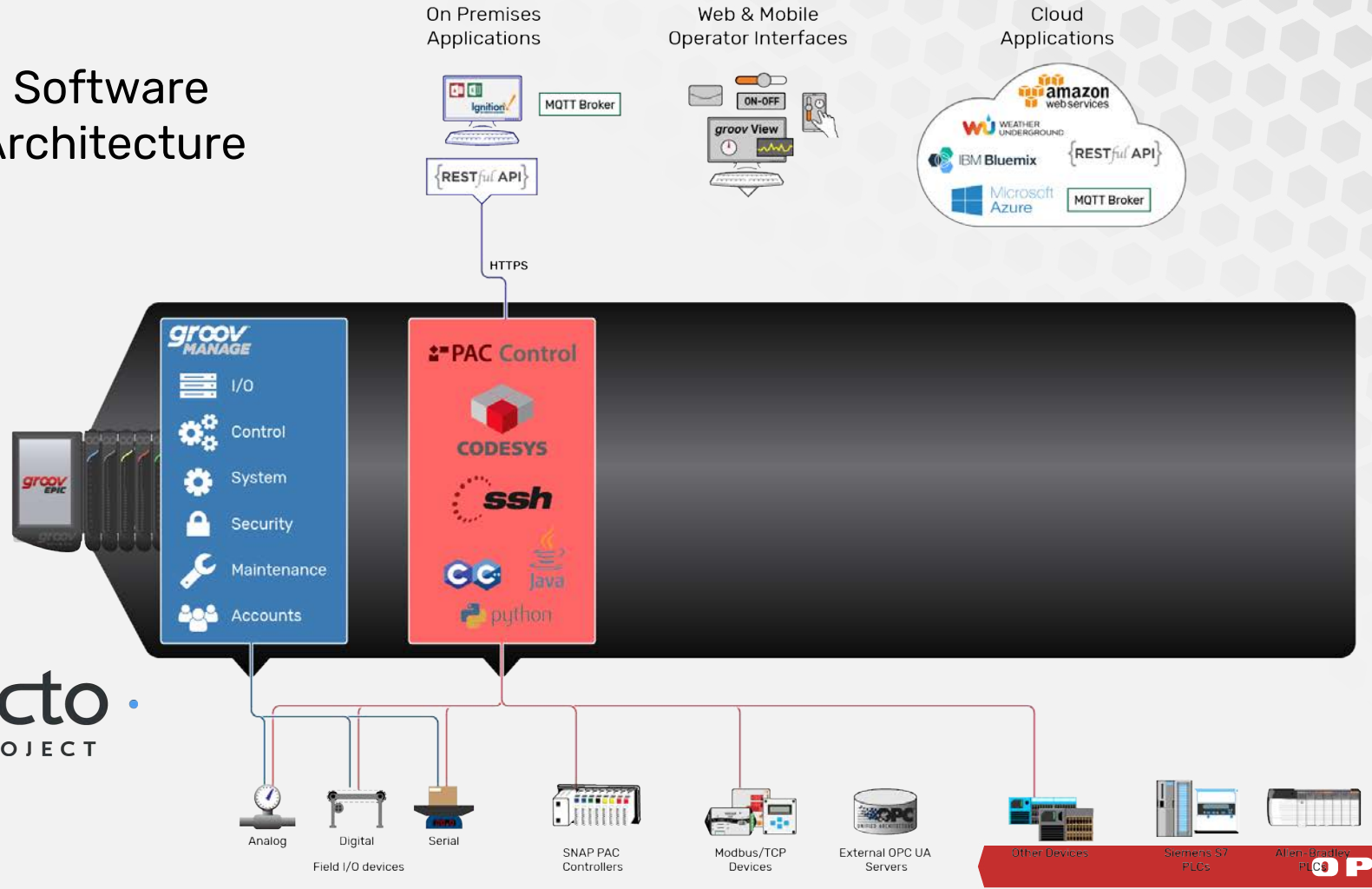
Software Architecture





groov Manage

Software Architecture



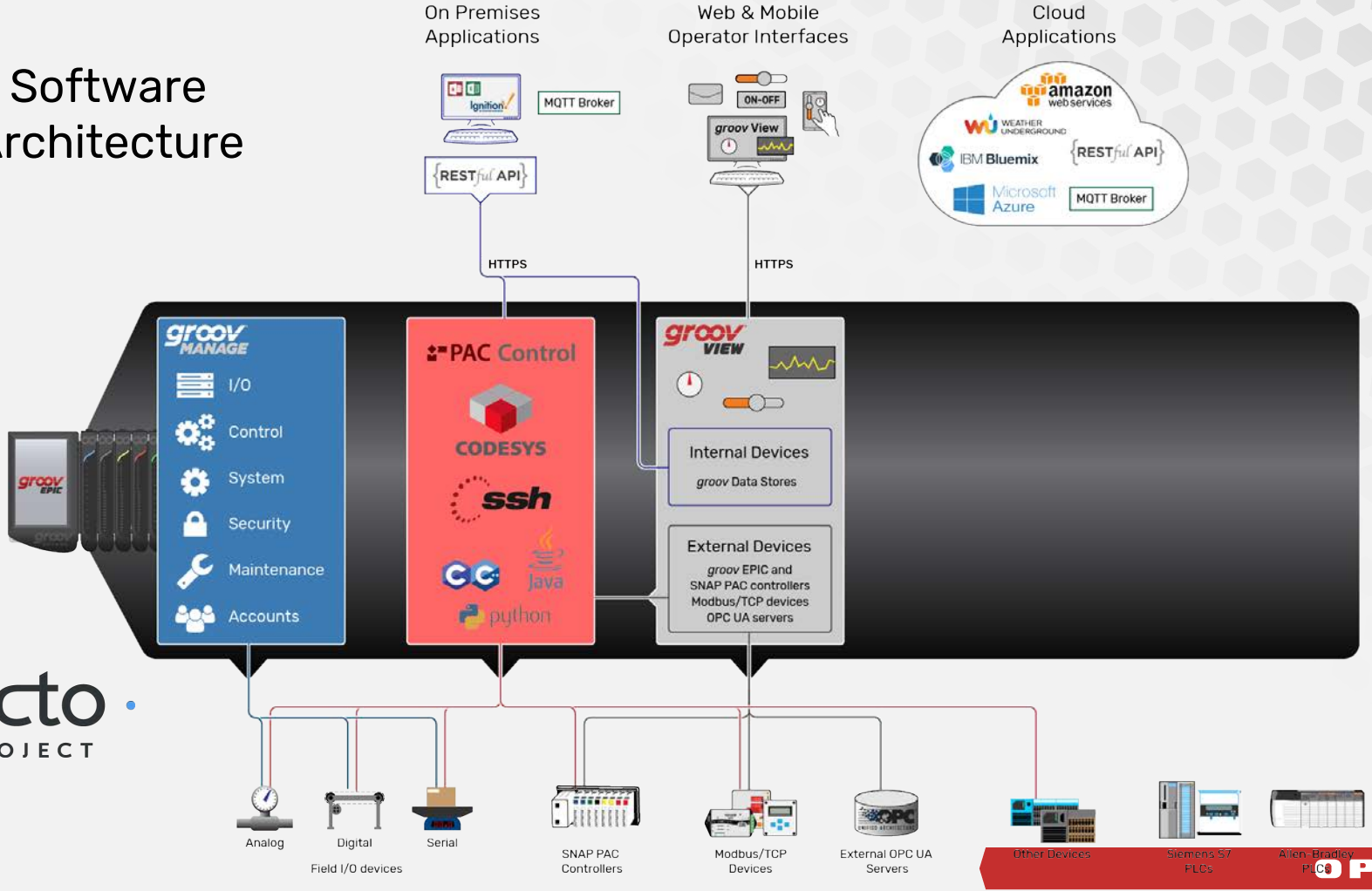
yocto PROJECT

Multiple Programming Options

- PAC Control
  - Flowchart-based control programming
  - Basic-like scripting engine
- CODESYS
  - IEC-61131 programming environment
  - Ladder logic, function block, etc.
- Secure Shell
  - Develop your own applications
  - C/C++, Java, JavaScript, Python, etc.

CODESYS

Software Architecture



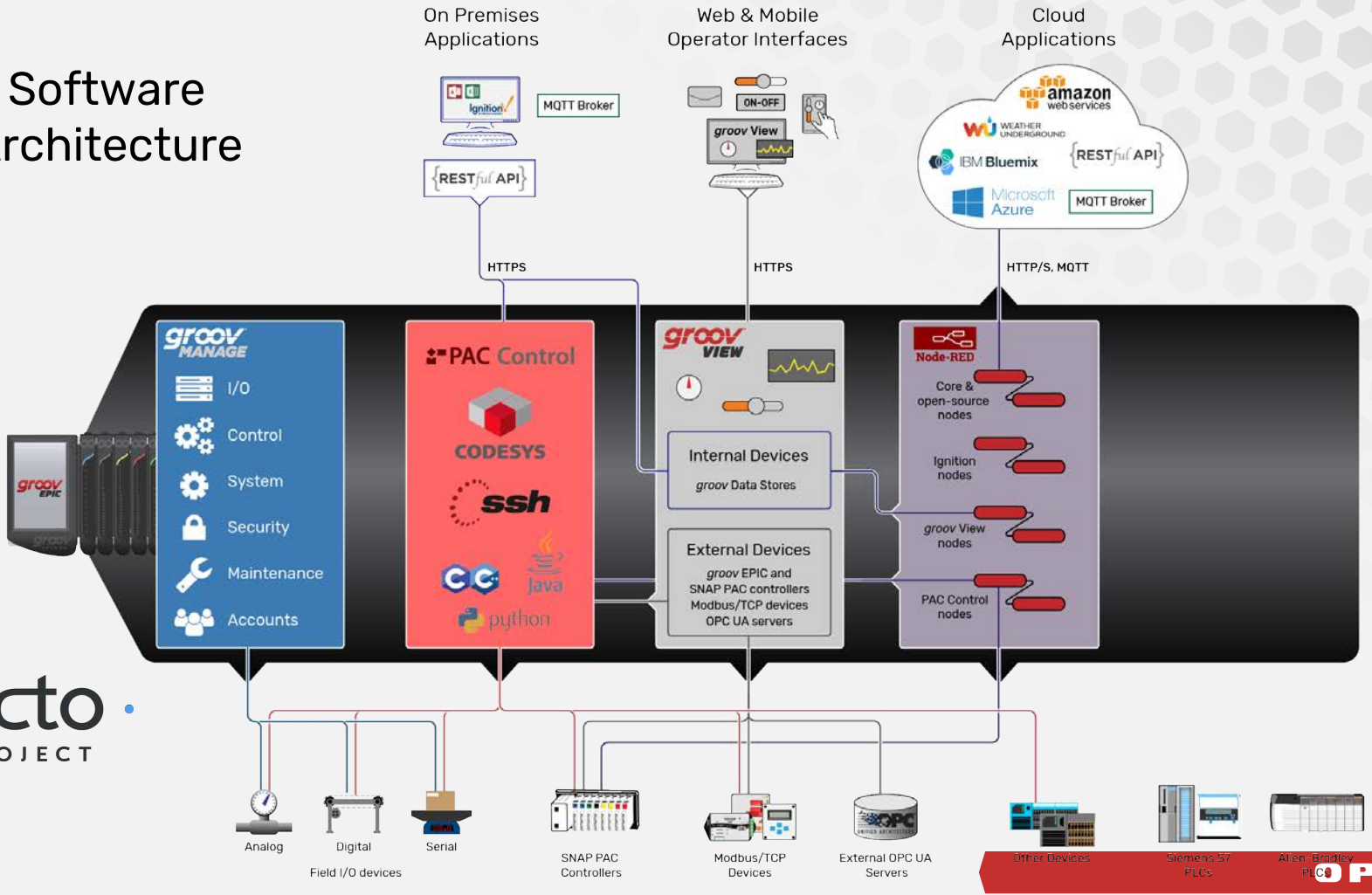
yocto PROJECT

groov Manage – *groov* View

groov VIEW

OPTO 22

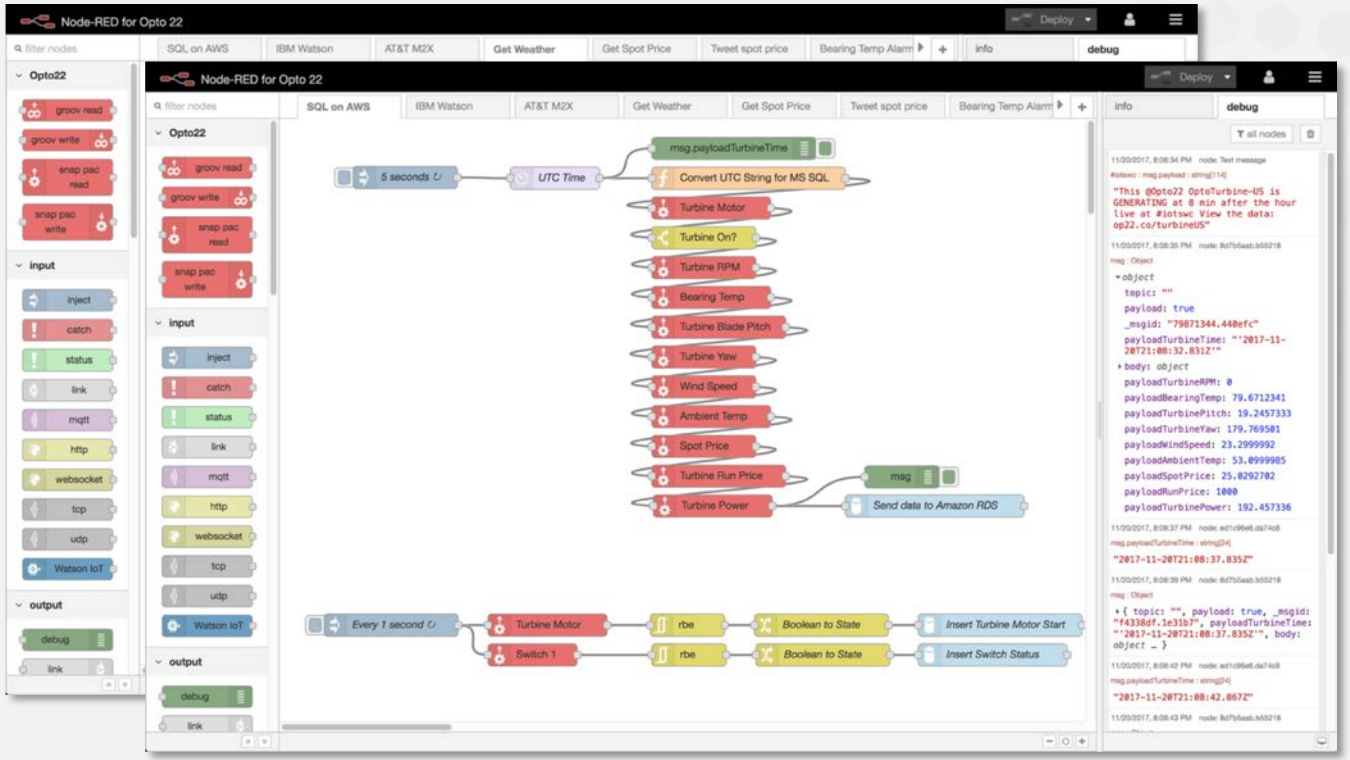
Software Architecture



yocto PROJECT

groov Manage – Node-RED

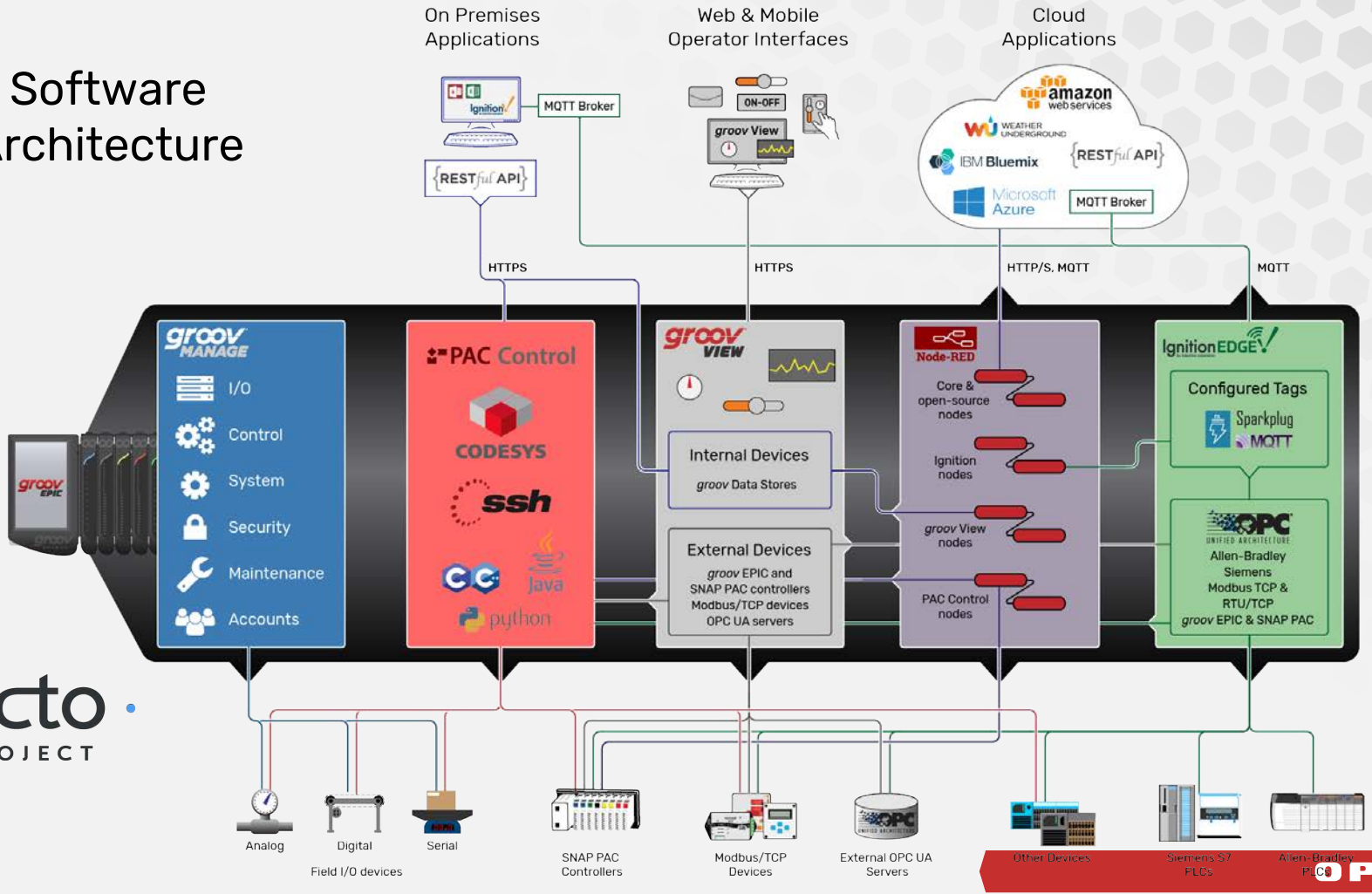
Node-RED IIoT Development



Node-RED

OpenJS Foundation

Software Architecture



yocto PROJECT

Legacy PLC Connectivity

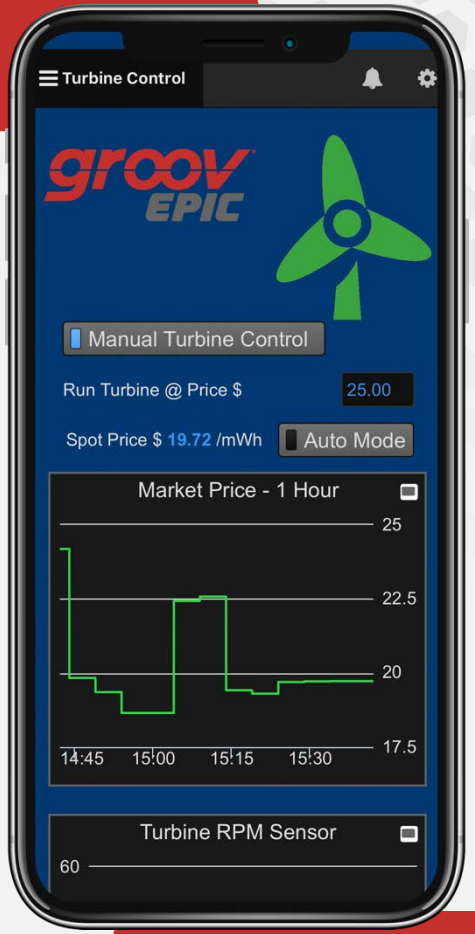
- Embedded drivers to PLCs
  - Allen-Bradley Logix, SLC, PLC5, and Micrologix
  - Siemens S7-300, -400, -1200, -1500
  - Modbus/TCP and Modbus/RTU over TCP
  - SNAP PAC S- and R-Series
  - *groov* EPIC PR-series

Live Demos

Get your smartphone ready…

Live Demo - local

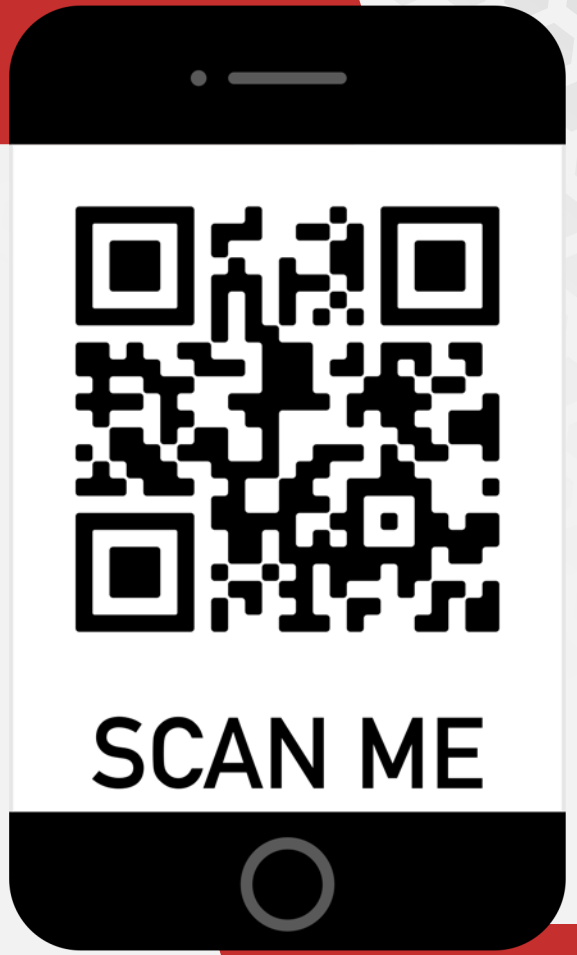
- *groov* EPIC connected to **model turbine** and **stack light** for monitoring and control
- Connects to **CAISO API** via Node-RED to determine market spot price
- Connects to **Dark Sky weather API** for local weather data
- Publishes time-series data to **MS SQL** database on AWS RDS
- Publishes real-time operating data to **MQTT broker** for consumption my cloud-based SCADA *(groov View/Ignition Gateway)*



Live Demo - cloud

- View real-time live ELC Turbine data from your smartphone
- View time-series data from MSSQL database on AWS
- View live status updates on Twitter @OptoTurbineUS

- Credentials:
  - Username: **trial**
  - Password: **opto22**



Thank you!

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